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ABSTRACT

The purpose of the paper is to present a model and suggest hypotheses relating the family as a social system to the concepts of human and natural energy. Human energy is interpreted as the capacity of humans, in this case, family members, for doing work and natural energy as resources such as natural gas, carbon dioxide, and heat. A behavioral model of social systems based upon 1975 research by sociologists Frederick L. Bates and Clyde C. Harvey (Batesian Model), is used to describe the mutual responsiveness of family behavior to culture, personality, interaction, and situation. Characteristics of a role in the Batesian model are: (1) behavior performed by one actor; (2) interaction with another actor or with a unit such as the family; (3) acts organized around the performance of a function; and (4) occurrence within a physical setting. Human energy and natural energy resources are important factors in many phases of family life. For example, families export energy outputs to other parts of society by working and attending school; import energy by hiring workmen within the home; and release nonhuman energy waste flows such as carbon dioxide, heat, and waste matter. Families also export and import information when family members interact and exchange information with social groups and organizations other than the nuclear family. Twenty-three hypotheses generated by the Batesian model of family and energy information conclude the paper. (Author/DB)

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ENERGY AND THE STRUCTURE OF SOCIAL SYSTEM: SIGNIFICANCE FOR FAMILIES

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This is a report from Agricultural Experiment Station Project 3142, Functioning of a Family Ecosystem in a World of Changing Energy Availability. The entire research team, faculty and graduate students, contributed to the on-going project and, by their support, to the completion of this report: Anne Field, Peter Gladhart, David Imig, Bonnie Maas Morrison, Lawrence Schiamberg, Mary Zabik, Joanne Keith, and Michael Lawrence. The work of the research team has been implemented through the Institute for Family and Child Study, a unit of the College of Human Ecology, specifically designed to expedite cross-disciplinary family and child research.

ENERGY AND THE STRUCTURE OF SOCIAL SYSTEMS: SIGNIFICANCE FOR FAMILIES*

Dennis R. Keefe**

Introduction and Statement of the Problem

There has been a growing interest in the analysis of families and social phenomena in general from a systems point of view (Bates and Harvey, 1975; Broderick, 1971; Buckley, 1967; Hill, 1971). There has also been an increasing awareness of and interest in the problems associated with energy and material resource shortages. While the latter problems are implicitly compatible with and briefly dealt with by social systems analysts their functioning within social systems has not been the focal point of these approaches. They have been the focus of ecosystems approaches (Hook and Paolucci, 1970; Sims, Paolucci, and Morris, 1972; Steidl, 1969). However, it is my possibly biased feeling that the sociological potential in these latter approaches is still underieveloped. In short, no adequate theoretical model as yet exists which links a rigorously developed model of social system behavior to the ecological concepts, matter-energy and information. Cottrell (1955) was a sociological pioneer in this enterprise but the macro-historical, institutional approach he used is not conducive to the analysis of specific family behavior systems. An anthropologist, Adams, has just published a new work (1975) which looks exciting but probably will not satisfy the sociologically curious.

The objectives of this paper are two, one descriptive, and the other analytical. The first is to unpack and make explicit the conceptual linkages between a model of the family as a social system and the concepts, matter-energy and information.

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Since the behavior of the occupants of family positions is not structured by energy criteria per se but rather energy related roles (behavior involving energy), the Batesian model of social systems (Bates and Harvey, 1975), which is a behavioral model, will be used. The second objective is to suggest some analytical hypotheses relating family and societal variables to matter-energy and information variables.

Assumptions of the Batesian Model

In the Batesian model social systems are assumed to be comprised of behavior, including overt, cognitive and affective behavior streams. In addition, the concepts used to describe the structure of behavior are also based on movement or behavior. Thus, societies are comprised of groups and organizations; the latter are comprised of positions which are collections of roles, and roles are made up of acts. Thus, the parts of social systems are all the same (behavior or acts); systems differ only in their organization. In addition, the way the parts are interrelated in (social) space are also defined in terms of behavioral role relationships. The boundaries of systems are defined in terms of bilateral role relationships, and the boundary crossing linkages with the environment are defined in terms of reflexive (between positions occupied by the same actor) role relationships.

The concept, "function", is also defined behaviorally. The function or a role is the contribution its behavior makes to the behavior of the larger system of which it is a part. A structured environment is assumed to exist outside the social system and its changing relationships with the social system are treated as a key determinant of social system change. Since an optimal relationship does not always occur between the social system under investigation (organism, or "O") and its environment ("E") the existence of stress within the system is possible.

Behavior is "caused" or explained by the mutual responsiveness of four categories of variables, culture (C), personality (P), interaction (I), and situation (S). As Bates and Harvey indicate (1975, 33, ff.) this is not an uncommon set of explanatory variables. However, instead of treating them as separate systems and/or simple independent variables, as has been done by Parsons and others, Bates emphasizes the mutual responsiveness of all of them within the same system. For example, societies and actors are treated as systems made up of the exact same behavior. While all of the behavior of an actor occurs in society, only part of it occurs in any one group, such as a nuclear family. Similarly, groups such as nuclear families are systems of behavior with active and inactive or latent phases (a nuclear family is not active all the time). Active phases are linked by culture (C), which is society in a latent state--rules guiding behavior stored in actors' brains. Since all behavior occurs in, and was learned in interaction (I) and situations (S) with material and social objects, norms (C) are tied to I and S, and cues from them act as triggers which activitate C.

The Structure of Energy Interchanges Between Social Systems

Social systems exist in structured environments. Nuclear families exist in extended kinship systems which are part of society which, in turn, is part of a larger ecosystem. Nuclear family groups and extended kinship systems are a part of the division of labor of society. As such they are systems of behavior which capture and transform energy in the process of solving certain problems for their participants and posing others to be solved by them or by other parts of society (Bates, 1974).

They capture inputs such as continuous direct non-human energy flows (food, electricity, etc.), discrete capitalized (indirect) non-human energy inputs in the form of goods, tools, etc., indirect capitalized human energy (human capital) e.g., of children's education and parents' marital counseling,

in the form of the behavior of family members, nannies, butlers, chauffeurs, etc. Families also directly capture or are indirectly bombarded with information inputs. The distinction between direct and indirect information inputs is here made on the basis of the degree of control families have over the input. Some information is acquired or expected as a result of the performance of family roles and is, in effect, feedback (requesting and receiving a Sears Christmas catalog, dollar income, bills, bank statements). Other types of information are unexpected, the result of a nearly random bombardment process (receiving junk mail). Of course, the ability of a family to process information is directly related to the family's degree of control over its acquisition or the extent to which a family's information importing role structure is mapped onto society's information exporting role structure.

The distinction between direct and indirect non human energy can, I think, be made on the basis of flows versus stocks. In the former case energy is used once and immediately disposed of. In the latter case, energy forms are used more than once. For example, Pampers and natural gas are direct flows and diapers and batteries are indirect energy (capitalized) stocks. The distinction between direct and indirect human energy can, I think, best be done on the basis of behavior or capacities for behavior. Thus, when a family hires a plumber to fix a leaky pipe it is importing a specific function or set of acts. This energy is kinetic--or a direct flow. Once the pipe is fixed, the behavior is gone. However, when a family sends a member to trade school to learn plumbing the family imports capacities which can be used many times--and probably for a variety of functions. This capitalized form of potential energy is indirectly available at all times.

Families then convert these inputs (transform energy) and export the outputs to other parts of society. Some examples are, adults prepared to work and children

readied to be molded by schools (human capital), shopping behavior (direct human energy, garbage (indirect non-human energy) and direct non-human energy waste flows such as carbon dioxide, heat, waste matter, etc. Families also export information. Some is directly controlled (feedback), as when want ads or mail orders are placed, bills are paid, or when a letter requesting redress is sent to manufacturers. Some is indirect, or less controlled. In the latter case, a family's behavior, its possessions, etc. are a constant source of potential information about its lifestyle. As with information importing the distinction is a matter of mapping between family and societal role structures.

These O -- E exchanges occur via two mechanisms, member sharing and interstitial groups. We all participate in multiple group situations, taking outputs to one group and bringing inputs back. This is because many of the roles in each family position are extramural roles, i.e., in order to fulfill their expectations the occupant must leave the family group and become a member of another group. The provider role in the husband/father position is one of these. The actor, at different points in time, is a member of both his nuclear family group and the organization for which he works.

Member sharing may provide a mechanism for the exhange of non human matter--energy. Thus, a mother who works at a grocery may bring home food at a lower cost because of her membership privileges. However, the unique linking function of sharing is that it is the mechanism for importing and exporting of human capital--indirect human energy. Between the time a worker leaves his job at five o'clock in the evening and returns to it at eight o'clock the next morning his human capital is restored. This is an output of the productive activities of the nuclear family elemental group and the actor's membership in it. This is what I understand to be what Parsons calls the latency-pattern maintenance function of families.

Similarly, other groups and organizations in society increase the capacities of actions to perform family roles (increase their human capital) and export these capacities to families. Because family members are also members of other productive elemental groups such as marriage counselling groups, prenatal classes, religious and secular socializing classes, congregations, etc., actors bring particular skills, norms, etc. to their parental, spousal, filial, etc., roles.

Not all human capital is appreciated in elemental groups (we learn from our experiences in interstitial groups, too). Nor are all elemental groups structured to primarily increase human capital. Nevertheless, where incrementing human capital is of primary concern, the argument here is that elemental productive groups are most uniquely adapted to the transformation of energy into this form and that member sharing is the structural mechanism for the exchange of it.

In the Batesian model interstitial groups are those non elemental, non productive groups formed when the members of two elemental groups meet and negotiate for the transfer or exchange of outputs. They perform coordinating or exchanging functions. When the shopper interacts with the checkout person in a grocery store, that shopper is not a part of the store's organization. Nor is the checkout person a part of the shopper's family. Most O -- E exchanges which do not primarily involve the incrementing of indirect human (capital) energy probably occur via this mechanism.

The openness of a family behavior system is a direct function of the complexity of the extramural role relationships of the members with the outside system. However, it is useful, I think, to point out that distinguishing between these two input mechanisms encourages precision when dealing with openness and closedness in social systems such as families. Thus, nuclear family groups may be relatively open to those energy forms acquired via interstitial groups. These do not become a part of the family; rather they are merely used by the family (goods, services, and direct non human energy flows such as electricity). On the other hand, nuclear families tend to be relatively closed when it comes to sharing its membership. At the direct human energy-behavior-level, there are only a few ways in which one can become a member of a nuclear family. At the indirect human energy-capital-level nuclear families tend to be relatively careful about whom they let develop the capital of their members.

The Functions of Matter Energy and Information in Social Systems

Having looked at some of the structural aspects of social systems and how family systems are linked with their environment, it is time to examine in more detail the functions which matter-energy and information play in such systems. Assuming with Bates and Harvey that functions are inferences made by analysts, a few introductory comments are in order about the theoretical stance taken by this analyst. First, the functions described here will be specified at a relatively high level of abstraction. While this is desirable for theoretical economy, hopefully, specification at lower levels of abstraction will eventually become possible for more applied or practical reasons. Second, the conception of matter-energy and information functions will be structured according to the Bates and Harvey definition or role. It is at the role level that behavior is most meaningfully analyzed in the Batesian model. Bates defines a role as behavior performed by one actor in interaction with an alter in a physical situation where behavior consists of a stream of acts organized around the performance of a function (Bates and Harvey, 1975: 92). Note the interplay of the key CPSI variables.

First, a role consists of behavior performed by one actor. Thus, direct human energy is expended and indirect human energy (human capital) is depreciated and/or appreciated. I suggest that the function of direct human energy is thus to drive role behavior and the function of indirect human energy (human capital) is to support role behavior. Human capital represents the capacity of the personality component (P) to perform expected roles. It includes stored energy, information, norms, and attitudes, and is, therefore, uniquely capable of appreciation with use. If the actor is capable of meeting role demands then this element of the system is positively contributing (functioning) to the activities of the system. If this component is lacking in skills, education, etc., then it becomes a source

of stress Bates calls role inadequacy (Bates and Harvey, 1975:359). Another implication of this element of the role definition is that, since behavior occurs through time, roles occur through time. Of course, the amount of time utilized per role may vary and the number of roles performed per unit of time may vary. If the demands on time are compatible with the available supply of time, then no problems of this type occur. However, if the demands on time are too great, then stress occurs of the type Bates labels role saturation (Bates and Harvey, 1975:368).

The next defining characteristic of a role is that it occurs in interaction (the I component of roles) with an alter. Thus, the direct human energy of at least two humans is being expended and the human capital of at least two humans is being changed. This interaction occurs either in adjacent time/space locations or in adjacent locations followed by behavior performed by one actor, as when one member of a family communicates a shopping need to the occupant of the family shopper position and this request is carried out. Here we note that, in addition to occurring through time, roles occupy social space. Roles are related to each other in space either bilaterally (in positions occupied by more than one actor) or reflexively (in positions occupied by the same actor). Since interaction is involved the two actors involved must define the situation the same in order for the system to function smoothly. When this is not the case, Bates labels the ensuing stress role nonreciprocity (Ibid:366).

The third defining characteristic of a role is that it consist of a stream of acts organized around the performance of a function. There are two interesting implications in this. Since it is the cultural component, norms (C), which structures behavior around the performance of a function, the question arises as to what activates C to an active state. Bates indicates that one triggering function is performed by the behavior of an alter. When we interact (I) with others we

receive very specific cues, i.e., information as to when certain role performances are appropriate. Another source of information which performs a role triggering function is change in the situational component (S). The cues in this case may be less specific. Thus, a new set of roles are triggered when a child moves from the dinner table to a playroom. New sets of roles are also triggered when an actor receives information about the movement of a clock, the sun, seasons, the price of gasoline, etc.

Another source of triggering information is the behavior of the actor (P). Here it is important and useful to consider what else is in P besides stored norms. The following is adapted from the Bates model of personality (Bates and Harvey, 1975: 35, ff). First, there is a physiological behavior subsystem (P_p). There are a variety of physiological entropey--negentropy cycles which send information to the actor's brain, triggering roles. For example, there is the food energy cycle where digestion and exercise processes produce hunger information triggering eating or eating preparation roles which rebuild energy stores, yield satisfaction, and lead to disposal roles. Rest cycles include exercise and physiological entropy which produce fatigue information triggering rest behavior, a negentropy process and eventually, waking behavior. The growth process performs several functions. In addition to producing information about, e.g., sexual needs, food needs, exercise needs, etc., it also affects the capacity of the actor (human capital) for energy and information capturing and utilization. Thus, maturation and aging are associated with the acquisition and sloughing off of roles. There is also a sexual entropy--negentropy cycle in actors which sends information to the brain which triggers certain roles. Similarly for illness--health cycles.

The cognitive behavior of the actor (P_c) also sends information to the brain triggering ideational behavior, affective behavior, physiological behavior, and overt behavior. Affective behavior of the actor (P_a) does the same thing. Changes in mood, other feeling states, attitudes, belief systems, etc. send information

to the brain which triggers affective, cognitive, etc. behavior. Similarly, the overt behavior of the actor (P_o) is a source of triggering information. Roles may occur in sequences where the completion of one (cooking) may trigger another (serving, eating, etc.).

In the above subsystems of P information from one subsystem may trigger behavior in any or all of the others. They all involve energy transformations, but the function of information, per se, is to trigger or activate roles from an inactive (C) state to an active (behavior) state. Since information is also functioning to deactivate roles once the feedback information signals the appropriateness of this, perhaps the function should be generalized to that of switching (on or off) and monitoring.

The other interesting aspect of this third defining characteristic of roles relates to the performance of functions per se. As an actor moves through time/space he plays many different roles in a variety of different groups, performing as he goes, a variety of different functions for a variety of different systems. Thus, it is quite possible for any one actor to be faced with norms which conflict with each other. For example, it may be impossible for a wife/mother to adequately satisfy the nutritional expectations of her children and the taste gratification preference of her husband. When this occurs Bates labels this type of stress as role conflict (Ibid.:349).

The fourth defining characteristic of a role is that it occurs in a physical setting (S) and involves the use of physical surroundings, implements, resources, etc. Thus, direct non-human energy resources are involved in role behavior. Such resources as food, electricity, gasoline, oil, natural gas, etc., of course, come to mind. But role behavior also involves the depreciation of indirect energy inputs capitalized in constructed things (appliances, other durables, etc.). I suggest that the functions performed by these non-human energy resources are to

support and amplify role behavior. They also perform a flexibility function because of the energy which they store (in refrigerators, hot water heaters, etc.). One does not have to play water heating roles every time one wants hot water. Nor does one have to interact with a source of fresh food supplies every mealtime. When these physical supports from the environment are inadequate for the performance of roles, Bates labels the ensuing stress as role frustration (Ibid.:363).

Since non-human energy resources are so intricately involved in behavior systems there are two structural aspects of these interrelationships that affect the functioning of them in behavior systems. The first has to do with the number of actors which may or must use non-human energy resources. We can tentatively label this bilateral role replication with non-human energy resources (the two rows in Table 1). Some resources are private, in that behavior involving the good or energy flow is at any point in space/time restricted to one actor. Clothes, toothbrushes, and wedding rings are examples. Other goods or flows are public in that if one actor uses them other actors may or must also and frequently at no extra cost. Cameras, radios, television sets, automobiles, etc. are of this type.

The other interesting structural aspect has to do with the number of roles any one actor can perform with a good or energy flow. This may be labelled reflexive role specialization of energy use (the two columns in Table 1). Some goods are very specific in the number of roles which may be performed with them. There is not much that one can do with a clothes dryer except dry clothes, with the possible exception of display prestige. There may be other exceptions, but other goods and energy flows are more generalized in the kinds of roles they support. For example, houses support a variety of roles. So do automobiles, clothes, yards, etc. When you cross these two dimensions the four cells in Table 1 are generated. Hypotheses involving these concepts are developed in the next section of this paper.

Table 1. Non Human Energy Role Supports Classified By Degree of Bilateral Replication and Reflexive Specialization

Number of Actors per Good or Flow:	Number of Roles per Actor: Reflexive Specialization	
Bilateral Replication	Few -- Specialized	Many -- Generalized
Few -- Private	Specialized -- Private Husband's Ski Boots	Generalized -- Private Husband's Clothes
Many -- Public	Specialized -- Public Family's Camera	Generalized -- Public Family's Backyard

The functioning of matter-energy and information in structured behavior systems is summarized in Table 2. Direct human energy functions to drive role behavior. Indirect human energy (human capital) supports or provides capacities for role behavior and provides flexibility by its storage function. Direct nonhuman energy supports and amplifies role behavior. Indirect nonhuman energy supports and amplifies and provides flexibility by its storage function. Information about all of the above triggers, deactivates, and performs a feedback monitoring function.

Table 2. Matter-Energy and Information Functions in Behavior Systems

Input type (Energy)	Energy Functions	Information Functions
Direct Human	Drives	Switches, Monitors
Indirect Human (Cap.)	Supports, Stores	" "
Direct Non Human	Supports, Amplifies	" "
Indirect Non Human	Supports, Amplifies Stores	" "

The Significance for Families: Some Hypotheses

In this final section of the paper I would like to suggest some of the more interesting and interrelated hypotheses generated by the above model of family and energy-information linkages.

1. In general there is a positive relationship between the number of goods or the quantity of direct non human energy flows controlled by a family system and the number of roles performed by that system.
   a. However, if the goods controlled by a family are specific to intramural roles and family members are tied up in extramural roles (working, for example), the intramural roles will not necessarily be activated (see Eichenberger, 1975, for a case involving household appliances energy usage by employed and unempoloyed housewives).
   b. The reverse would also be true.
   c. To the extent that household production goods are labor-saving items (automatic dishwashers, etc.) they may not generate roles but allow for role reallocations and thus depress the relationship in hypothesis 1.

d. To the extent that family consumption goods are labor-generating items they would tend to enhance the relationship in hypothesis 1.

2. The amount of non human energy (and therefore roles) available to a family system is positively related to the complexity of the division of labor (degree of specialization, affluence) of a society.
3. The amount of non human energy captured by a nuclear family group is an inverted-U shaped function of the family life cycle (although the per capita energy available may be a U-shaped function).
4. The quality of life of a family system is an inverted-U shaped function of the number of roles performed per unit of time.
5. The ratio of private to public goods controlled by a family system is a positive function of the division of labor of society and the family's participation in it as evidenced by its income level.
6. The ratio of specialized to generalized goods controlled by a family system is a positive function of the same variables.
7. Generalized goods carry more functional burdens than specialized goods.
8. The number of functional burdens which goods must carry is directly related to family size and inversely related to per capita income levels of families.
9. Goods which carry many functional burdens tend to be key aspects of peoples' lifestyles and rallying points for voluntary associations and social movements.
10. The more generalized a good (the more roles it is used with), the more complex is the evaluation of feedback pertaining to it.
11. The structural aspects of energy forms for nuclear families (where member families get them, who uses them, who owns them, where outputs are destined, etc.) are a function of the division of labor of society and kinship systems.

12. As nuclear families move through their life cycles, the types of goods acquired and used change from specialized--private to generalized--public and back to specialized--private.

13. As goods used by nuclear family members become more private and specialized, the number of opportunities which encourage autonomy within the system increases.

14. As finite energy and material resources become more scarce and costly families will substitute generalized and public goods for private and specialized goods, thus decreasing opportunities for autonomy.

15. A high degree of bilateral replication in the use of public goods will be a potential source of role non reciprocity in nuclear families.

16. Families experiencing role non reciprocity will be less able to respond effectively to changes in information about public goods availability.

17. The degree of family role non reciprocity will be inversely related to the felt levels of satisfaction from the use of public goods such as housing.

18. Families with high levels of role non reciprocity will sacrifice efficiency in the purchase of public goods, and pay for this by being able to purchase fewer private goods. A positive feedback loop is thus encouraged forcing even less autonomy in a system that "needs" it.

19. Increasing energy costs will cause family members to experience role frustration in being unable to get the resources needed to perform roles in accustomed ways.

20. The degree of role frustration experienced will be inversely related to nuclear family dependency on non market energy exchanges within their extended kinship systems.

21. As energy resources become more costly, economic roles will increase in importance, giving rise to more role conflict in energy capturing roles.
22. Role inadequacy will be inversely related to energy crisis coping ability.
23. As finite energy supplies increase in cost, families will substitute labor intensive roles for non human (capital) intensive roles, thus encouraging role saturation.

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